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Traditional Building Construction in an Historic ArabianTown

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Introduction

This study of traditional building construction and the organisation of the building industry in the town of Al Muharraq in the State of Bahrain is based upon a survey of about a hundred buildings, (mainly large two-storey courtyard houses), constructed between 1790 and 1939, as well as documentary research at the India Office Records and Library and interviews with those personally acquainted with the pre-war industry. There are no extant structures in Al Muharraq earlier than 1790 and no written records on building prior to the appointment of the first British Political Agent in 1900[1]. It is argued, however, that techniques altered very slowly and so it may be supposed that nineteenth and twentieth century structures provide clear indications of those methods employed in preceding centuries. This study was undertaken between 1983 and 1988[2] and I know of no other comprehensive research into the subject. Bahrain, a group of small islands in the Arabian Gulf, has played a crucial economic, cultural and political role in the region since the dawn of civilisation (see Fig. 1). Its architecture displays unique characteristics, but is also representative of a wider area. Al Muharraq is, however, the only historic town remaining on the south side of the Gulf since others have been largely demolished, except for small areas and "museum" buildings. Ultimately, this will also be the fate of Al Muharraq. There is little in the literature on its architecture and construction[3].

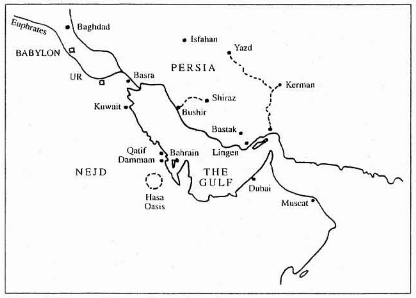


Fig. 1 General Location Map

The building form and architectural design have been described in detail elsewhere[2] and although it is not the present purpose to describe building design, it will be helpful to illustrate the general concept. Typical house forms are shown in Fig. 2, with typical elevations in Fig. 3. Courtyards are surrounded by single storey structures, one room deep. Staircases ascend to roof terraces from the courtyards. The terraces and upper rooms were used in summer. The design ensured low thermal capacity and captured cooling breezes by the use of ventilators (badgir), or other climate control techniques, which made their appearance in the Middle and Late Periods (1890 - 1930 and 1930 - 1940).[4]

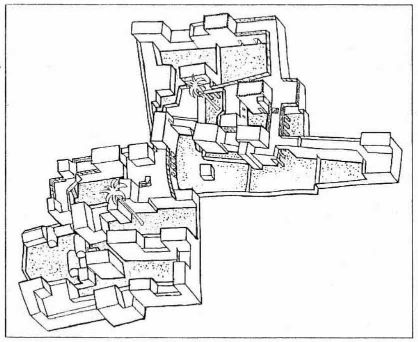
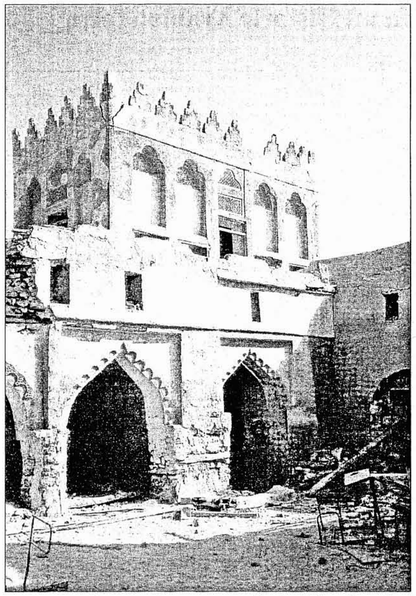
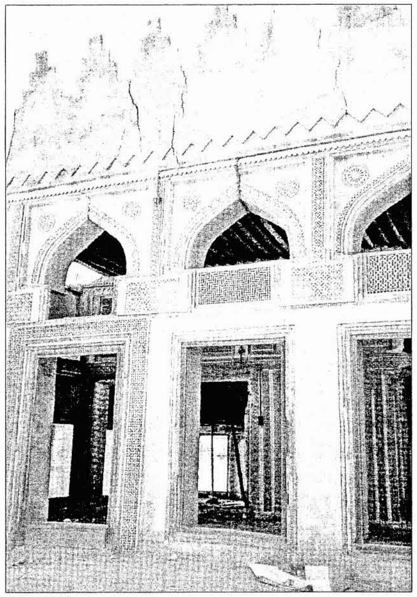


Fig. 2 General House Form (Sheikh Abdullah & Mattar houses.)





Typical Elevations, both in Sheikh Hamad House.

Fig. 3a First floor apartment, accessed by roof terrace, above ground level liwan or portico.

Fig. 3b Sheikh's majlis seen from roof terrace. Note various types of plasterwork decoration and merlons.

Themes

Apart from intrinsic interest, the main justification for this study is that the town is fast disappearing and little studied, although it is the last remaining example of a type which is central to technical diffusion processes covering great distances and vast spans of time. Arguably, techniques changed little over many centuries, and methods over the last two hundred years give valid clues to methods over millenia from, say, Uruk V (3000 BC) to the Second World War, as well as from the Indus Valley to Mesopotomia and from Persia and Central Asia to Zanzibar and East Africa. This is of value to archaeologists as well as architects. One justification for this study therefore concerns technical diffusion and technochronology.

A second theme concerns the construction industry organisation and the impact of economic change. This should also be seen as an integral part of the technochronological story. It might be expected that increasing organisational sophistication would affect profoundly the technological capability of the industry, and contrariwise, that new technical possibilities would require new forms of organisation. This would also be driven by changes in the amount and distribution of disposable income, due to economic development, and also by the impact of regional political change upon trade patterns. For example, the defeat of piracy and the emergence of the *Pax Britannica* in the 1860s allowed the growth of steamship routes to India and the Persian seaboard. Also, the defeat of the Ottoman Empire led the British to transfer their regional seat of power from India to Baghdad in 1920. The rapid growth of the pearl trade flowed from this, followed by the emergence of the oil industry.[5] This led to a rapid growth in disposable income, the emergence of a unified high-wage labour market; the decline of the tribal monopoly on construction, and the loss of special trade skills, as well as the mass-production of ready-made components; the emergence of

builders' merchants and the import of new tools and components (such as door handles) and materials (such as stained glass, iron bars and Portland cement).

Thirdly this study deals with public health and the impact of institutional change. Here also, the relatively plentiful data on Bahrain may be a useful indicator of conditions in less well-documented towns- even in the distant past. So long as development densities were low, and the city occupied high ground, pit latrines would not pollute the wells. Where pollution occurred, construction of septic tanks did not solve the problem because firstly, densities had soared due to Sharia law on inheritance and secondly because development expanded on to coastal areas virtually at sea level. The random quality of street layout and property boundaries meant that, in the absence of modern public institutions, incremental sewer construction could not create continuous falls. This led to the emergence of a serious concern with town planning. A municipality was created in the 1920s at the insistence of the British Political Agent, Major Clive Daly, and the Ruler's Advisor, Sir Charles Belgrave. The BPA obtained a copy of the planning regulations from Quetta, and these were applied to Bahrain.[6] A Land Registry was established in 1927. The consequence was grid layouts, wide and straight streets, regular smaller plots and internal lavatories. This in turn affected the aesthetics of design, the regularity of layout on-plot (and the decline of the organic, incremental quality of urban form), leading to a far more standardised, almost modular building construction. One can see how the emergence of a modern state replaced irresponsible tribalism,[7] and these institutional changes interacted with medicine and construction.

Finally, another reason for this study is that superficial historical quotations are often made in contemporary Gulf buildings, based upon a misunderstanding of the relationship in the tradition between function, construction and appearance. Obviously a deeper understanding of historical construction will help improve the literacy of historicist design, or – better – stimulate contextualist design in which continuities of spirit and principle (and not mere appearance) link the past to the future.

Technical Diffusion

The French traveller de Rivoyre, visiting Bandar Abbas around 1880, wrote as follows.

> *"Dans les rues de Bandar Abbas, les habitations des Persiens et des Arabes se distinguaient d'elles mêmes. Le cachet ne manquait ni aux unes ni aux autres. Les premieres, gracieuses, ornamentées; les secondes, lourdes, massives."*[8]

This neatly sums the matter up for Bahrain as well. Also, Lewcock and Freeth[9] point out the similarity of buildings in Bushire and Bahrain, and Zwemmer[10] notes the large number of Bushiris in Bahrain. The Arab style[11] was based on mass masonry with external buttresses and internal niches, whereas the Persian style[12] was based on a structural frame, with non-loadbearing infill panels. Analysing the evolution of construction and aesthetics in Bahrain, it was concluded that the general trend was for Persian methods to infiltrate Arab methods from 1890 to 1930.

This process of change arose from the influx of refugees from Persia (and hence Persian taste) into the southern side of the Gulf, driven by unwelcome political reforms following the revolution of 1907–9.

Several tendencies are clear:

(i) Solids reduce and voids increase as time goes by: in other words, windows, niches and panels get bigger. Rooms get higher and longer.

(ii) For the most part, the elements of structure (piers and tie-beams) are more clearly and elaborately expressed on the facades. There is an increasing concern with regular and repetitive rhythm.

(iii) There is progressively less use of surface geometric decoration on facades. Where decoration does occur, particularly internally, it becomes orderly and delicate but less gorgeous. Decorative elements become increasingly pseudo-structural. In other words, they provide a visual and poetic exposition of the structure. Brackets and arches are the most common examples.

(iv) Each visual element is increasingly separated or articulated. For instance separate planes were given to tie-beams, piers, arches, shutters, upper or lower panels etc.

(v) There is general tendency towards a perpendicular visual stress. Merlons[13] are associated with a horizontal visual emphasis. Coping is associated with a perpendicular emphasis. There seems to be a visual homeostasis at work.

Expression of the structural frame was a key design impulse. The walls had always been strengthened by quartered palms laid horizontally and tied at the corners. This was a *latent frame* although not visually expressed as such at the outset. At that stage, the perceived reality was the solid wall.

One may conclude that at the turn of the century a new feeling emerged (although the process of gestation and growth precedes and follows on from that, no doubt). The latent frame which lay buried inside the stonework emerged from its hiding place to become the main visual expression. It could be argued that the motive was to reduce the thermal mass of the wall in order to cut radiation at night, and perhaps to economise on stone. However, these goals could have been achieved without any structural expression – as was done for the great *majlis* (or meeting room) of the Seyadi House. The truth is that the new style met aesthetic, technological and economic impulses in a fully synthesised way.

Obviously this note is intended to be neither complete nor authoritative. It does, however, highlight that construction technique is diffused in a somewhat similar way to language. It can be claimed that Bahrain and its adjacent region was throughout history the regional cross-roads, absorbing, transforming and transmitting onwards construction technique. What follows is essentially a descriptive account which may also prove to be a useful building brick in a larger structure of study of technical diffusion and change.

The Building Industry[14]

There were no architects in Bahrain until the post-WW2 period. A master mason (*al Banna*) would be engaged to construct a building and come to a verbal agreement with the client at each stage of the building process. The masons were chosen by reputation, not by tender, and the contract sum was agreed after the mason was chosen. No detailed construction drawings would be made, but in some cases a few rough sketches were drawn by the client or mason in order to communicate and agree basic requirements at inception. Otherwise things were agreed on site, perhaps drawing on the ground by sprinkling lime, or marking detailed requirements as to fixings and finishing on wall and ceilings. There were no building companies as such; all workmen were independent and were hired for a particular job; they owned and provided their own tools. There were certain places where workmen gathered, and the masons (and possibly clients) would inspect and hire some of the men. The usual contractual arrangement was call *al Maz*. The building owner and mason would agree a price for constructing a building as marked out on the ground, on the basis that all materials and joinery items were supplied by the owner: the mason simply organised site labour and directed site works.

Since there were no specifications and no working drawings, reliance was placed on the honesty and sincerity of the mason; in so small a community, a builder whose services were much questioned would soon be out of business. An unreasonable client likewise would spoil his family name and be subject to social pressure to behave correctly. There was a simple way of building, with a very narrow range of choice as to materials and components. Standards were well known and widely observed. Indeed, it was significant how many people of the older generation knew all about the traditional building methods. Even today older people who have never worked in the industry can discourse on the properties of materials and how they were produced. This technical knowledge appears to have been widely diffused in the community.

Doors and windows were available ready-made by the 1920s. Special items were commissioned by the client himself from a carpenter (*al najjar*) and brought to site by the owner on a hired donkey. Therefore, if the quality of fittings and fixtures was to be changed, this did not affect the contract sum. The mason would be paid at intervals as the job progressed up to the *maz* contract sum, and he would then pay the hired workers.

The building owner had to go to quite a lot of trouble to secure some materials, or so it would seem to us today. For instance, at one time it was common to hire a boat owner to bring gypsum from Qatar. He and his men would excavate it themselves with wrecking bars. Upon the boat's return, the building owner would hire a specialist burner to calcine the gypsum and pulverise it, and then hire a donkey to bring the material in a cart or panniers to the building site. To supply materials for a house could involve an owner in many separate operations of this type, and a good deal of organisation which now normally falls to the contractor's lot.

The size of the building industry (excluding carpenters, blacksmiths and materials procurement people) in the 1920s and 1930s was between 400 and 500 persons, (relative to a population of 20,000 persons). There were four main families from whom masons were drawn in Al Muharraq. The number of masons in each family was roughly as follows:

Al Hayki	30 to 40 masons
Al Sakran	25 to 30 masons
Al Banna'in	25 to 30 masons
Al Sadeh	20 to 25 masons

There were thus about 100 to 125 masons; of these, about a quarter would have been masters (*al astadh*) and three quarters would have been assistants or apprentice masons (*al musayed banna*). Entry to the trade was based on family membership, and youths would join uncles or fathers to learn their skill. There were no guilds and no formal examination to gain admission to the status of a master. On average there would be about three labourers per mason, but on good quality work there would only be two labourers to each mason. A labourer (*al a'mel* or *al koolee*) rarely, if ever, rose to be a mason.

Prior to the 1920s there had been considerable reliance upon the importation of men and materials from Persia. In 1900, the Political Agent, Calcott Gaskin[15], wrote to the British Political Resident in Bushire on the matter of the proposed new Agency building, requesting that building stone and other materials be imported from Bushire. He also noted that most labourers were farmers from Persia. In the 1920s and 1930s, however, most labourers came from Oman. Gaskin noted that *chendel* (rafter) poles were expensive in Bushire and Bahrain, and arranged to import them from Karachi.

In 1906, the Agent, F. B. Prideaux, indicated that there was a serious shortage of craftsmen and coolies in Bahrain. In a letter to the Agency at Lingeh he asked the Agent there to recruit men and send them to Bahrain. However, this reliance upon foreign sources may have varied, as building demand rose and fell, immigrant workers settled, or market prices fluctuated.

Construction Costs

A good deal of evidence on building costs for the new Agency can be found in the India Office Records.[16] The Agency consisted of Government of India offices and housing. It would have been simpler than the palace of a wealthy Bahraini as the Government was notoriously parsimonious. However, these are the only records on costs which could be found, and they throw considerable light on the industry at the time. In 1901 the new Agency design was shown on plan as about 17,000 sq. ft, and the total cost was estimated as 18,450 rupees (1 rupee = 16 annas; 13 or 14 rupees = £1 sterling). Items were as follows:

	Rupees
Bahrein Stones (1000 boat loads at R 3.5)	3500
Rafters (120 score at R20 per score)	2400
Bushreh (Basra) mats (1000 at 8 annas)	500
Date Sticks (850 bundles at R8 per score)	340
Clay (6000 donkey loads at R8 per 100 loads)	480
Gypsum (200 caras at R20)	4000
Teak planks (16 tons cubic)	2500
Carpenters' wages	600
Masons' wages	2800
Rods of iron (for windows)	190
Door and window fittings	200
Ceiling planks	150
Varnish, paint	270
Water	180

(1 cara = 490 kg.; an average boatload of stones = 7 cubic metres, according to Gaskin in 1903)

In 1905, and subsequently, more estimates were produced by F. B. Prideaux for major extensions to the Agency as follows:

Building	Area (sq. ft.)	Total (R)	Labour (R)	Contingency (R)
Guard house	900	650	100	50
Servants' houses	2000	2200	350	200
Stables	600	500	60	40

Gaskin's estimate (1901) indicates a cost rate of around R1.1 per square foot. Prideaux's estimates (1905) indicate cost rates of R1.1 (servants' houses), RO.8 (stables) and RO.7 (guard room). It subsequently emerged that the estimates were too low, and the job had to be skimped. It can be concluded, therefore, that R1.5 per square foot was enough for a good house, and RO.7 was a cheap price rate.

Gaskin's estimate of labour cost was just below 20 per cent of the total cost, and Prideaux's labour percentages go as low as 13 per cent for the stables. Presumably this reflected the relative complexity of design.

Costs given by Prideaux suggest that the frame, comprising stone, mortar and rendering, was 40 or 45 per cent of the total cost. The roof and floor elements were about 30 to 35 per cent of the total. Fitting out could be 20 per cent, but if economy was practised the cost could be less than 5 per cent.

Former builders stated that wages were about 2 rupees a day for an average mason and about 10 or 12 annas for a labourer. The figures varied from time to time and a labourer's wages could be as low as 6 annas in the depressed time during the 1920s and 1930s. Figures given by Prideaux in 1904 and 1907 are very similar.

Informants who had worked in the industry before the war suggested that about half the resources of the industry would be devoted to maintenance in a typical year. Major S. G. Knox, however, noted that the Government of India normally devoted 2 per cent of the capital cost of building to maintenance each year, but that in Bahrain, because of the aggressive climate and the poor materials, 3.5 per cent per year would be appropriate.

Mensuration

The human body was the measure of distance until recently; the units were the double armspan (*ba'ah*), lower arm from fingertip to elbow (*drah*), and spread hand (*shiber*). The mason would use his own body to set out the building by, for example, marking his fingertip position, placing his elbow on it, marking again, and so on.

Faroughy[17] gives some details on measures in which he implies that they were fixed quantities. For instance he says that a *drah* (or *dhra*) equals one cubit or nineteen inches. A *ba'ah* (or *ba'*) equals four *dhra* or a fathom, that is, six feet four inches. However, one informant implied that the lengths varied and depended on whose body was being used as the measure. Probably the truth is that the situation was in a state of transition from the latter system to the former as the requirements for accuracy increased. Knotted string was used to transmit dimensions. The size of an opening would be given to the carpenter in this way in order to produce correctly sized windows. The knot method was also used to establish the proportional geometry of a façade. For example, a string measuring the distance from a door to a corner might be folded into four to establish the distance between horizontal grooves.

Materials and Construction

The method of construction was a basic frame of stone piers and timber tie-beams. The piers and beams created rectangular voids, which were filled in by windows, doors, ventilators (*badgirs*), thin coral panels (*farsh*), plaster decorative panels and interior niches (*rosanna*): (see Fig. 4). Elements may have been combined; for example, two incised panels could be placed in the same void, one facing in each direction.

The span of the mangrove poles tended to create a maximum room width of about 3 metres; from this arose a comfortable length, which was usually about 6 metres. India Office files often refer to mangrove (or 'Zanzibar') poles of 20 feet, but these were expensive and also tended to sag and create problems of leakage. Another reason for narrow buildings was to help wind-cooling.

Exploitation of the qualities of the construction system gives a strong module, which governs the rhythm of façades, the volume or shape of buildings, and even the grain of the cityscape. This contributes to the sense of cohesion and unity. The mangrove poles came mainly from sites which at one time were within the Omani Empire. This included Bahrain. One can speculate that the trade patterns of this empire are responsible for some aspects of the traditional form of construction throughout the wider region of which Bahrain is only a part.

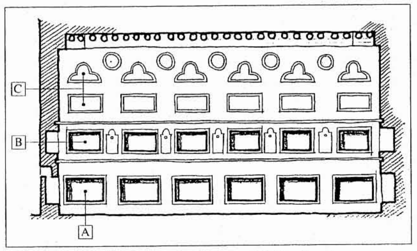


Fig. 4 Wall Infill Elements (Salman Mattar house, east apartment, internal or niche
Key: A = badgir or ventilator. B = rosanna or niche
C = incised plaster decorative panel.

Coral Block

Coral block (known as 'sea stone', *hadjar al bahr*) was calcareous gritstone used to build structural piers and walls. It was cut from the sea at low tide with picks, and brought to site as unshaped rubble. It is crystallised carbonate of lime, reasonably strong but very salty. This was used for building piers and solid walls (see Fig. 5).

Farsh stone is a regular bedrock stratum, also from the sea. It occurs naturally in layers up to about 7 cm thick. It was quarried by driving wedges into the strata and levering with a bar. This split the stratum off, sometimes in large areas which could then be trimmed with axes. This was used for infill panels between piers and also for partitions. It was used for coping in the Middle and Late periods. Sometimes a higher quality calcareous stone from the quarry on Jidda Island was used for foundations.

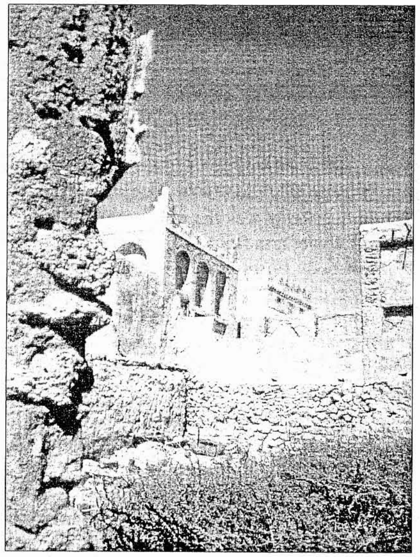


Fig. 5 Coral Stone Walling: this can be seen in the foreground

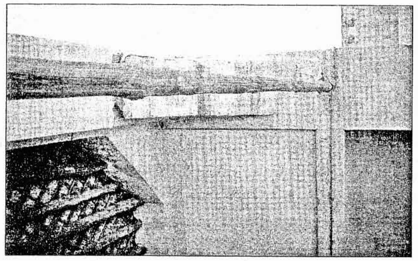


Fig. 6 Mangrove Pole, used here as both roof joists and cross-bracing.

Timber

Palm trunks (*yadhaw*) were quartered and used as wall plates and tie-beams. These were embedded within the masonry, with a vertical spacing of about 0.7 metres (or less if required to bridge over windows or other voids). Mangrove poles (*denchel* or *chendel*) were imported from the Malabar Coast (Calicut) and East Africa (Zanzibar, Lamu), and were used mainly for floor and roof joists (see Fig. 6). The wood is durable, very strong and amazingly flexible. Above the mangrove, was split banboo laid diagonally, and above that so-called Básra mats made of woven palm fronds. This supported a layer of small stones finished with mud (gatch) laid to a fall & drained to the street by simple wooden gargoyles (*marzam*.) In the Middle period, some roofs had a suspended ceiling framed by timber laths and hung from the mangrove poles. The Seyadi House has tacked-lath geometric decoration, and the children's room in Sheikh Isa House has the boards above the joists. Often fretted patterns were affixed (see Fig. 7).

Plaster and Mortar

Rifa'a clay (*tin al Rifa'a*) was brought from Rifa'a in the centre of the main island. This was produced by the weathering of the exposed rocks in the central depression. It was used to cement the rubble in the core of walls, and was also mixed with the lime mortar for certain purposes, perhaps to reduce the susceptibility of gypsum plaster to action by water, particularly on sulphates and other salts.

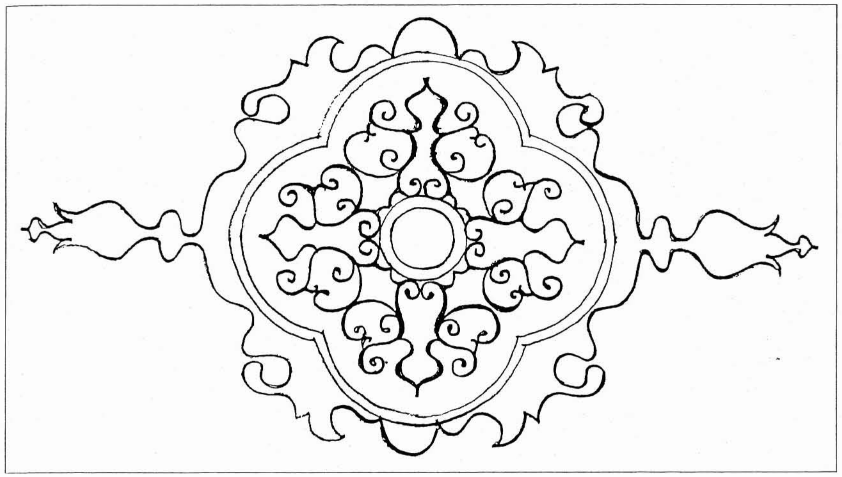


Fig. 7 Fretted Decorative Panel On Ceiling (Salman Mattar House Majlis)

Some mortar was made from burnt mud from the coral reefs. There was also a third source, a type of white mud that was collected at Bu Ghazal. Ship owners were commissioned by owners or builders to collect the mud and bring it to Muharraq harbour; this took two or three days. A donkey was then hired to transport the mud to the building site. This was too expensive for poor people prior to the 1920s or 1930s, and they used mud from the local reefs. The chemical composition of rendering on Sheikh Isa House was analysed by Hardy-Guilbert and Lalande.[18]

Djuss (gypsum) was used for rendering walls and roof surfaces. It was made by crushing and burning limestone. Initially the small cottage industry near A'ali was the only source, but more recently it was imported from Saudi Arabia and Qatar as it was less prone to crumble than the Bahraini product. Gypsum was made locally by building stones into a small dome and lighting a fire below. The workers would gather round a small pile of burnt stone and attack it with small wooden hammers, beating in rhythm and repeatedly calling out the name of God. The gypsum was mixed with lime (*nurah*) which improved its workability, particularly for external use. When supplies were imported from Qatar or Nejd (Saudi Arabia) to Muharraq, specialist burners calcined it by covering the stone with timber, which was set on fire. Prideaux, writing in 1906 on construction works on Agency land, mentions *saruj*, otherwise known as 'Lingeh cement'.[19] '*This saruj*', he writes, '*is valued here almost as highly as Portland cement for its power of resisting moisture in the soil*'. He says that he wanted to face all his buildings with it, but could only afford to do so to dado height. He mixed it with Portland cement. No doubt the expense arose from the need to ship *saruj* from Lingeh.

Plastering was done by the masons. There were commonly three layers of plaster. The first layer (*al tetrees*) was mud used to fill up the holes or major unevenness in the masonry. The second layer (*al misaih*) was mud, probably with gypsum added; this established a reasonably smooth surface. The third coat (*al tabidh*) was a smooth decorative coat of lime and gypsum. Only one very thin coat of gypsum, about two or three millimetres thick, was applied to *farsh* panels. The top coat was often set back about 3 cm from niches and windows on all sides to create a rebate moulding. The top coat was also sometimes omitted here and there to form inset panels as part of the decorative scheme. These might be rectangular or have semicircular or pointed heads, and so on. This was done by using wooden templates which would be temporarily fixed to the previous coat. Templates were also used to form the horizontal grooves and zigzag mouldings.

Incised plasterwork decoration was also done by masons. The panel was cast in a frame. Before the plaster was dry, a nail or sharp piece of metal would be used to set out the basic lines of the pattern; these can generally be seen looking closely at the finished panel. A straight edge was used to set out lines; for circles or arcs either two nails, joined by cotton thread, or dividers were used. Small knives were used for carvings. In the old days only the basic lines would be set out, and the more detailed parts of the pattern would be done by eye. The setting out itself was not planned carefully beforehand, with the result that many panels contain apparent errors (for instance, where a pattern unit cannot be accommodated within the panel).

Nowadays work is mostly cast from a carefully designed mould. The surface is smooth, whereas the old panels are rough. There is a mechanical perfection in the pattern geometry, but the spontaneous charm and tactile quality of the old panels has been lost. It would take a day to produce an old panel, but many can be cast by the modern method in one day.

Imported Materials

A modern range of imported materials and products came into use at the end of the last century. Iron bars of about one centimetre diameter became common in external window grilles. These were probably imported from Indian ironworks, possibly at Kulti or Jamshedpur. Locks, hinges, porcelain door knobs, bronze bolts and elaborately bevelled mirrors are to be found in many houses. The Sheikh Isa House has decorative cast plaster friezes on the built-in cupboards. These were obviously imported from Europe. The main European traders were German (for example, Wonckhaus, or Prins and Sturfers). The main British trader was the Mesopotamia and Persia Corporation, based in Karachi.

Most significant architecturally is the stained glass used in fanlights. This was available from about 1890 onwards, although no one knows from where it was imported. At one stage glass was made in Persia and Turkey, but one informant said he thought the glass had come from Danzig, although there is no evidence for this.

Construction of Arches, Stairs and Doors

All arches are false; they are decorative rather than structural. There is a structural beam above the apex of the arch, which rests on piers, and these may emerge as columns below the springing. Permanent pre-cast formwork was made from plaster about 5 cm thick. For pointed arches there were two halves on each side, whereas semicircular arches had one unit per side. These were propped from a timber joist between the piers. The bottom of the formwork was timber, but this was temporary. Layers of small lumps of coral rock and mortar were laid; each was left to dry before the next was laid. The final rendering abuts or covers the formwork which was

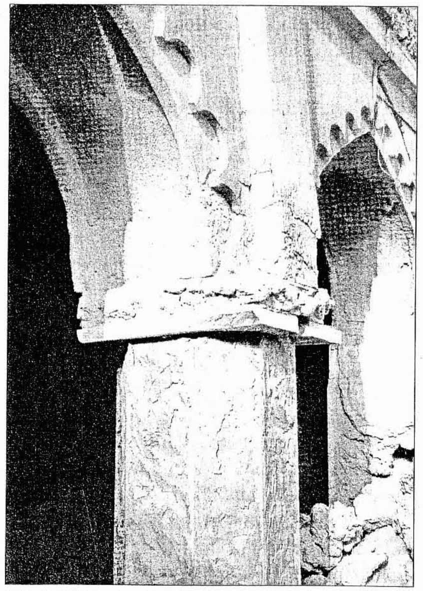


Fig. 8 Arch construction showing permanent formwork, with decorative rendering of extrados

left in position, and was often cut back to form a polylobed moulding along the extrados (or face). After removal of the timber formwork, the intrados (or underside) was rendered in a concave fashion. The whole strikes one as unstable, and yet it lasts very well, even in abandoned and derelict buildings (see Fig. 8).

There are a few staircases following the western pattern, for example from the Fakhroo House servants' court to the *majlis* terrace. However, the usual method was to form a single flight by laying about six mangrove poles from ground to first floor, supporting them with an intermediate sleeper wall if need be. The steps were then roughly formed from coral rubble and mortar, each step being held in position by the step below. It was then rendered. In later houses, small timber laths were laid over the rubble before the mortar was applied. The mangrove soffit was exposed (see Fig. 9). In the Middle Period, dogleg staircases and more complex arrangements were introduced, but the principles were still the same.

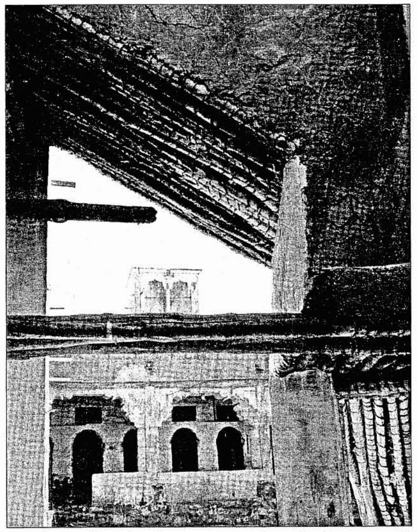


Fig. 9 Traditional staircase construction, showing exposed mangrove pole soffit. Note jute binding

Generally timber doors have two leaves. They have four or five tapering rails which are notched into the post. The post is fashioned into a pivot pole. There is a socket stone below and a socket rail

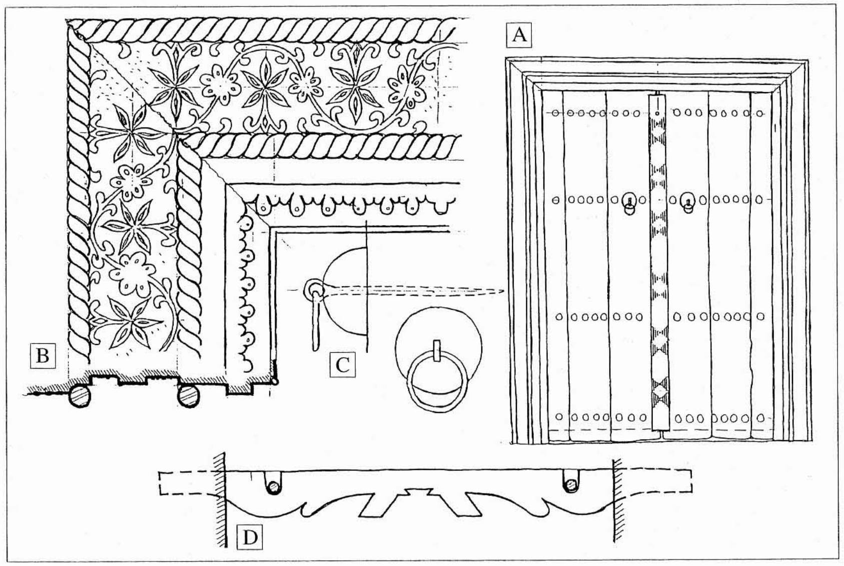


Fig. 10 Door: Sheikh Isa House Key: A = External elevation B = Architrave Carving C = Metal Knocker D = Upper Socket Rail

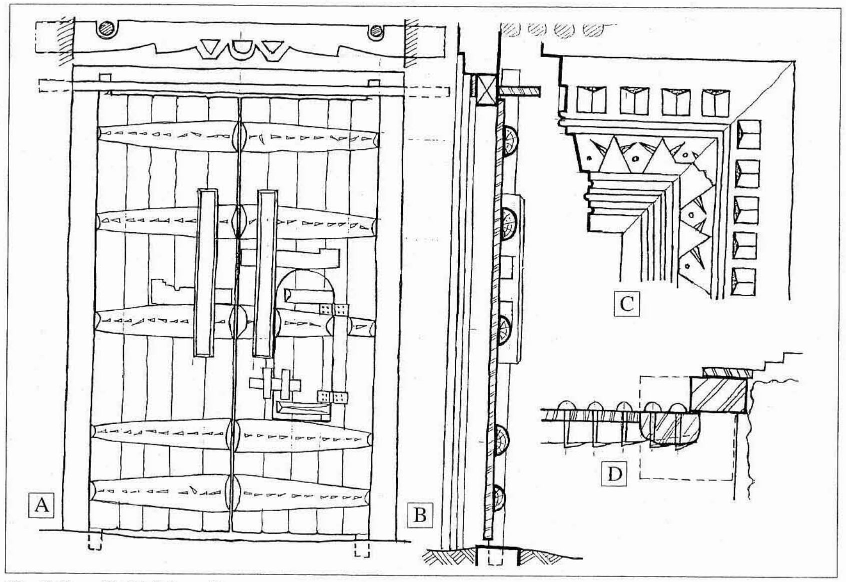


Fig. 11 Door: Sheikh Salmon House
Key: A = Internal Elevation with socket rail above B = Vertical Section
C = Architrave detail D = Horizontal section detail at grame

(about 20 cm x 4 cm) above, which is built into the wall on each side. This is carved. There are about three vertical planks fixed with dome-headed iron nails. The nails form visually distinctive rows on the outside, and are simply hammered over on the inside (see Figs.10 and 11). The doors still swing very easily even in abandoned property. Door knockers are thin, wrought iron hemispheres loosely fixed by a nail. The nail has a looped end from which the ring knocker hangs. Prior to the Middle period there are two horizontal sliding wood bolts and a wood hasp on each leaf of the door, making a symmetrical arrangement. The design of window shutters closely resembles that of doors (see Figs.12 and 13).

Design for Climate

The architecture of Bahrain, particularly in the Middle and Late periods, solves most ingeniously the problems posed by the climate. This was a major factor in building design and construction. It is particularly important to understand the function of the wind tower and *badgir* (wall ventilator). They utilize the principle that wind speed increases when funnelled from a wider to a small aperture. A wind tower has four faces of about 7 to 10 square metres open area. The central diagonal walls funnel the wind, whatever its direction. The negative pressure on the leeward side draws air up from the room. At night when there is no wind a 'stack effect' is created whereby the hot air inside rises up the tower and draws in cooler air from outside. An example of a wind tower is described in Fig.14.

The *badgirs* may be within either the parapet to a roof terrace or wall panels on the street side of rooms – usually at first-floor level but sometimes on the ground. There are two *farsh* panels; the upper panel is about 15 centimetres inside the lower (the gap being purely horizontal). The upper panel is supported on a small pole spanning between coral block piers (see Fig.15). The effect of

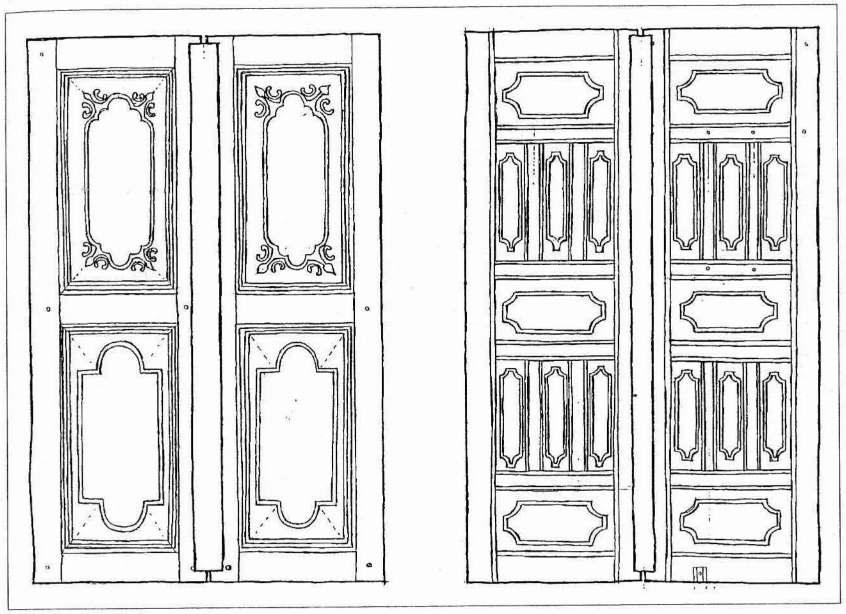


Fig. 12 Shutter Designs

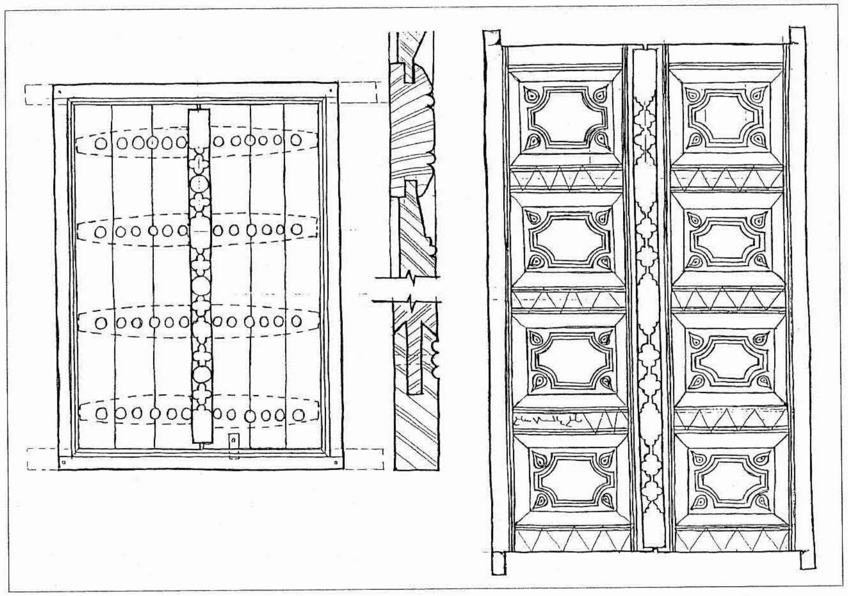


Fig. 13 Shutter Designs

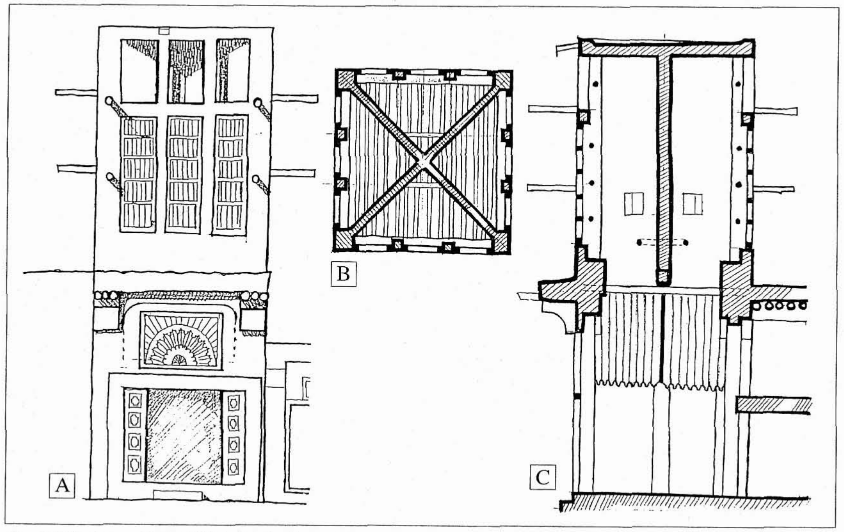


Fig. 14 Windtower (Roda 1125 in the Suq.)
Key: A = Elevation to Street B = Plan section of Tower
C = Vertical Section

these devices is quite startling – a refreshing breeze is created even on a comparatively still day, and it is brought down to sitting or sleeping level. Wall materials (gypsum, coral and *farsh*) have low thermal capacity and do not heat up much. They also have good insulating properties, allowing little heat to pass. Rooms for summer and night-time use were on the roof, where the thin *farsh* panels lost their daytime heat very quickly. Ground-level walls were usually thicker. This kept the occupants warm on winter nights. The incised decorative panels may have voids behind them, in order to trap air and so reduce thermal capacity as well as increase insulation.

Windows never have glass except for the fanlights, which are stained to reduce glare and thermal transmittance. The window screens allow air movement but cut down heat and glare, and also preserve privacy. There are shutters to retain daytime heat in the room on winter nights. Shutters also cut out high winds or driven dust. Muharraq is exceptionally humid, and it was very important that wall and roof materials allowed the passage of water vapour. The

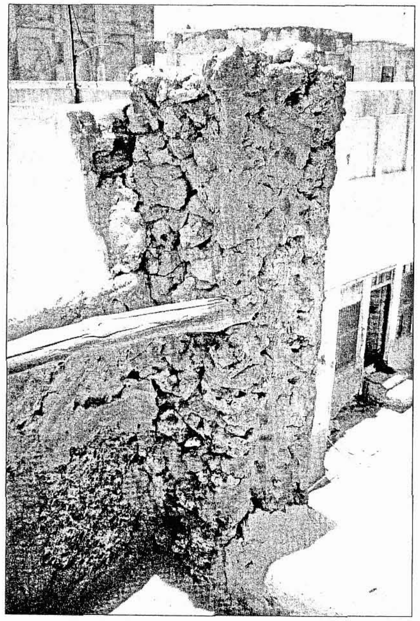


Fig. 15 Construction of Roof Badgir. The inner/upper farsh panel has collapsed, but the supporting pole is still in place.

plaster would absorb some vapour, and therefore little condensation arose; it might have been unpleasant as well as damaging to the plaster and the timber structure. Low thermal capacity and high reflectivity ensured that the wall surface did not heat up very quickly; it remained cool to the touch and did not expand or crack as much as other materials such as Portland cement. Annual maintenance was vital to seal cracks which would admit rain in winter. Rain

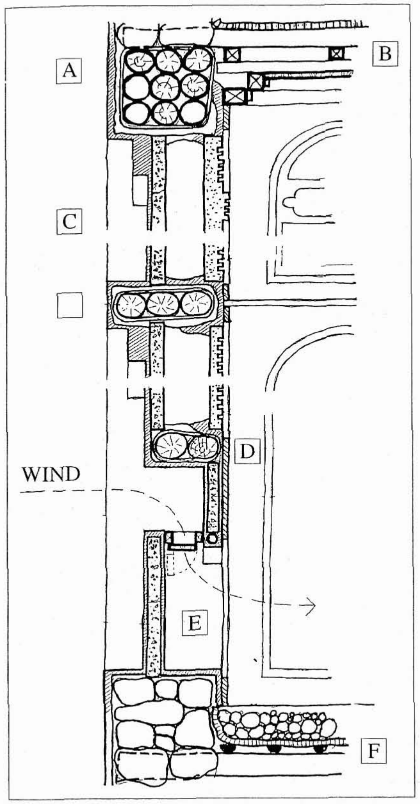


Fig. 17 Construction Cross Section
Key: A = Wall plate = mangrove poles bound with jute rope B = Roof structure = similar to Figure 16, plus suspended ceiling with t.g. boarding on soffit. C = Farsh panel (coral lamina) externally & incised decorative plaster panel inside, with void between. D = Tie beam = mangrove poles E = Room badgir or ventilator: two farsh panels with horizontal shutter. F = Floor structure = earth mortar (gaddad) on stones; then woven palm froud matting on split bamboo supported by mangrove joists

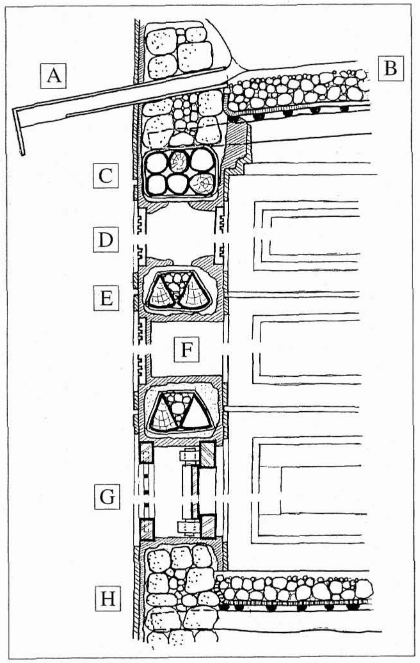


Fig. 16 Construction Cross Section
Key: A = Marzam or gargoyle B = Roof structure = stone & earth on woven palm matting, supported by diagonal split bamboo on mangrove joists. C = Wallplate: mangrove pole bound with jute rope. D = decorative plaster panels inside & out, with void between E = tie-beam of yadhow or quartered palm F = niche G = window with privacy screen outside & shutters inside H = First floor structure - similar to roof: see above

would leach out the mud, which was cementing the rubble core. The salts would then attack the plaster; crystallising behind it and causing it to spall off the wall. The various aspects of the foregoing analysis are illustrated in three constructional sections, drawn vertically through outer walls at first-floor level of different buildings. These show how the components mentioned here were assembled into a completed building (see Figs. 16 to 18).

One should not leave the subject of construction without some mention of tools: those old examples found by the author are illustrated in Fig.19. Before the 1920s, iron came from recycling ships' anchors. After that, small sheets of

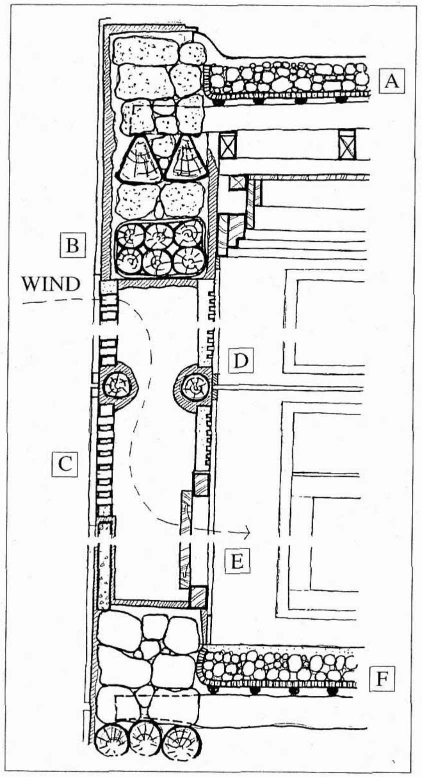


Fig. 18 Construction Cross Section
Key: A = Roof Structure = gaddam & stones on palm-frond mats; then split bamboo on mangrove joists. Also a suspended timber ceiling, with t.g. boarded ceiling B = Quartered palm wallplate bound to joists by jute rope. Then lintol of mangrove poles. C = Two rows of pierced plaster panels externally D = Two rows of decorated plaster panels, not pierced E = Internal shutter F = Floor structure, similar to roof

Swedish steel were imported, from which local blacksmiths made simple saws. An Iranian travelling trader regularly brought a sharpening stone, which blacksmiths and craftsmen used if tools had gone blunt since his last visit.

Building Form and Orientation

A thin, long building, one room wide would seem to be best because it would have maximum exposure to wind and least resistance to cross-ventilation. If it were oriented with its long axis east-west, (that is, facing north-south), this would minimise heat gain from the sun. The prevailing wind is north-westerly, and one would expect to find the *badgir* walls facing north-west or within 45 degrees of this orientation for maximum benefit.

A study of building layout using aerial photographs taken by the Royal Air Force in 1951 suggests that buildings generally do not follow this rule, but so many are post-war constructions (using air conditioning) that this may be a poor indication. Of the houses studied in detail, 33 have first-floor apartments. Of these, 17 are orientated correctly for the climate (facing north-south). Five of these have the *badgir* on the north wall, four on the south wall, and eight have no *badgir*. A more detailed analysis shows that in the Early and Transitional periods,[20] ten apartments were wrongly oriented and two correctly. However, in the Middle and Late periods, 15 rooms were oriented correctly and six wrongly. It may be that people became aware of the value of correct orientation around the start of the Middle period (about 1890). But it is clear that other layout factors such as privacy, affect the direction of the badgirs more than does the prevailing wind.[21]

Health and Sanitation

The earliest comments on health in Bahrain seem to have been made by Captain R. Mignan in *A Winter Journey* (1839), which is quoted at length for its general interest:

> *"They (the divers) suffer from cutaneous diseases and inflammation of the eyes, which in its effects becomes as painful as the Egyptian ophthalmia. They never attain any great age, notwithstanding their habitual abstemiousness, and although*

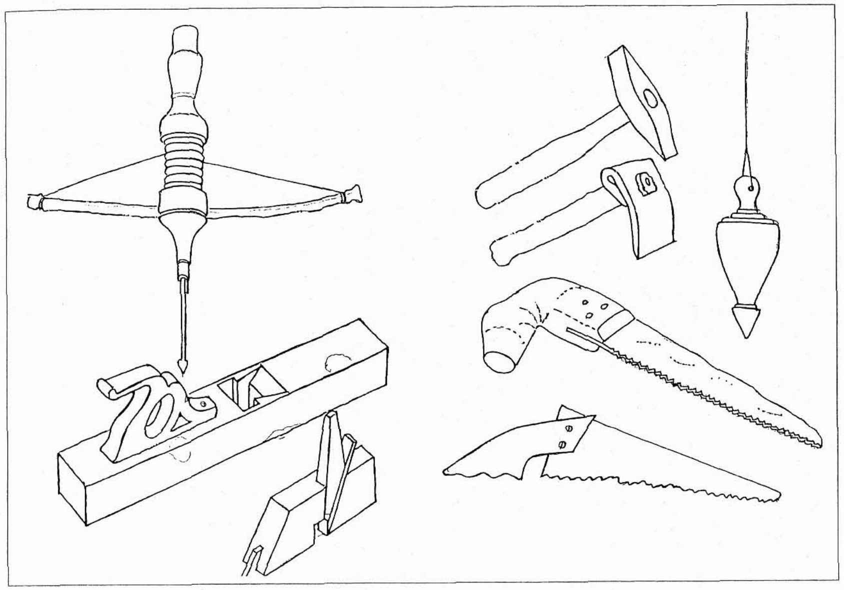


Fig. 19 Various Tools

> *they cultivate the beard, it is by nature weak, scanty and soon turns gray. They wear no other covering than a cotton kerchief, girt around the loins by a number of small leather thongs of the thickness of whipcord, and of so lasting a nature as to endure the whole period of their lives. Their heads have no other shelter than an immense bush of hair anointed with fetid grease."*[22]

The state of public health at the beginning of this century was poor. American Medical Mission records provide much information on the situation in Al Muharraq. Disease control by the Municipality in the late 1920s, and the drilling of artesian wells, brought great improvements. Dr Stanley Mylrea, a doctor with the medical mission, records that in five years he lived through two epidemics of cholera and two of bubonic plague. An epidemic of plague was expected in alternate years, and the cholera epidemics were terrifying. He writes:

> *"They swept into Bahrain like a forest fire and people died by the hundred within a few hours. A man would collapse in the street and in no time be in his grave. Panic would completely undermine the public morale. There were instances where a family would be wiped out, and I was in more than one house in which there was not a single occupant – just men, women and children, lying dead. It was difficult to get corpses buried."*[23]

Dr Harrison[24] notes that almost everyone older than thirty-five suffered from chronic rheumatism, perhaps due to diving or going barefoot (although rheumatism is also caused by Guinea worm). Eye diseases were very common and many people went blind. Dr Lucy Patterson wrote: *"About 75 per cent of people seem to have eye trouble of some sort. Trachoma, trichiasis, ulceration and opacity are the commonest forms."*[25]

Malaria was a serious threat until the Municipality eradication programme took effect in the late 1920s. Dr Patterson also draws attention to tuberculosis:

> *"Tuberculosis is terribly prevalent ... Pulmonary tuberculosis is common enough, but it appears to be outnumbered by the cases of tuberculosis of the bones, joints, skin, peritoneum, etc... The thousands of divers from Bahrain and Kuwait suffer a good deal from ear trouble and seem specially disposed to tuberculosis. This is not surprising when we know many of them expectorate blood for a week or two at the beginning of the diving season."*[26]

Parasitic diseases, such as Guinea worm and Madura foot were common until artesian wells became the main source of water supply. Life expectancy data are available only from 1965, when it was 58.4 years, rising in 1981 to 65.9, an annual increase of one per cent.[27] A projection backwards at a compound rate suggests a life expectancy of about forty-two years in 1920. This resembles the expectancy in some underdeveloped countries today, and so may not be an unreasonable guess.

Generally one or more cesspits were dug for each house into which 'black' waste was deposited. Cesspits were quite soundly constructed with coral blocks while waste water might be thrown on the ground, where it would be quickly absorbed. Generally there was about one lavatory for every one or two apartments, located at roof level, if possible in a small room adjacent to each apartment. It comprised a round hole with a channel drain, surfaced with mortar. Originally the pit was located directly under the hole, but more recently a cast-iron pipe would pass down the external wall face to a cesspit in the street. Zahra Freeth, (a Gulf resident for many years,) writes of Kuwait:

> *"In humbler homes part of the roof was often used by women as a privy. Excrement dried in the hot sun, and would later be swept up and collected as a fertiliser for the small market gardens on the edge of the town... Large numbers of the male population used the edge of the sea without benefit of cubicles."*[28]

Al Muharraq was probably settled originally on the high ground in the middle of the island. It was there possible to dig a deep pit into the coral rock, and the waste would soak away with no difficulty. When development densities were low, the infection of well water probably did not have a serious effect on the health of the population. The low-lying areas have a high water table, however, less than two metres below the surface. This created two problems: first, the wells became seriously polluted with faecal matter, which would have been the cause of cholera and typhoid outbreaks; secondly, the cesspits flooded frequently because they were never de-sludged. The trouble was aggravated in winter by rainfall, which, in the absence of storm drainage, filled the cesspits. In recent times, more fat in the diet of local people no doubt made the digestion process in the cesspits work less well, and there were frequent overflows of polluted water down the streets, at least in winter. As the cesspits became more troublesome, owners constructed drains outside their property. According to the Ministry of Works sanitation engineers, there is an extensive system of drains pre-dating the 1920s. There is no evidence that they were constructed or co-ordinated by a public agency, but most probably owners or families built the length of drain outside their property at different times with no reference to an overall design. Consequently no one knows the extent of the system. Generally sewers have a square or rectangular section, and are lined with coral blocks. The depth varies, and there is no consistent gradient to an outfall; the invert levels go up and down. Such polluted drains created an ideal habitat for rats, and, as rat fleas transfer disease to man, this was no doubt related to the serious incidence of bubonic plague.

Conclusion

How successful was the form of construction and technology used in Al Muharraq? There were some who were not happy. The Political Agent, Captain D. L. R. Lorimer, disliked living in the new Agency premises. He was very distressed by draughts, damp, and leaking roofs. He criticized the lack of fireplaces and the extreme cold in winter. He blamed all this for Prideaux's rheumatism and sciatica as well as Major Knox's "serious illness". He commented on roof construction as follows:[29]

> *"It is impossible to keep the roof in proper repair because to add fresh layers of mud or gatch only accentuates the mischief and makes the roof unsafe. Hollows are formed on the surface of the roofs in which water collects and remains until it has filtered through the cracked and defective substance of the roof... When there is heavy rain the dining room is quite uninhabitable."*

He later commented on the problem of damp ground, which was common on the periphery of Al Muharraq:

> *"The ground on which the Agency stands is barely above high water-level and is by nature damp. The material of the buildings is of a highly absorbent nature. There is further no proper drainage and when heavy rain falls large sheets of standing water are left until they are gradually absorbed by the ground. In due course, this water is drawn up by the buildings. The floors of the ground floor become damp and the damp spreads up all the walls to a height of 4 or 5 feet inside and out alike."*

Comments like these highlight some not untypical problems, but they arise less from the innate faults of the system than from errors in its use. For example, British architecture in the Gulf made no use of local wisdom; thus building plans were too wide, and so caused poor cross-ventilation and sagging roofs; no use was made of badgirs and wind towers, and so on. If the administrators had sought local advice, then probably Prideaux would have avoided his sciatica.

On the whole, architectural forms in Al Muharraq were able to solve many environmental problems very elegantly, effectively and economically, while using a narrow range of materials. Obviously there were shortcomings: heavy maintenance bills, leaking roofs for a few days in winter, rising damp on low-lying, poorly reclaimed land, and ingress of dust. Perhaps these were inevitable, given the limitations on choice of materials. Within those limitations, the response to the problems is impressive; indeed it is more impressive than that of modern building which, even with air conditioning, reinforced concrete and the curtain wall, displays less ingenuity, economy and elegance than is found in historic Al Muharraq.

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References

1. Bahrain was a protectorate and the British Political Agent was half-way between ambassador and governor. The BPAs in the Gulf towns reported to the Political Resident, Persian Gulf, based in Bushire and, until 1920, he reported to the Govt. of India. The major source upon which modern writers, such as Rumaihi, Khuri, Al Tajir and E Nakleh, rely is *Bombay Political Proceedings* held by the India Office Records and library, and particularly perhaps the memoranda of Francis Warden.

2. J. R. Yarwood, '*Al Muharraq-Architecture, Urbanism and Society in an Historic Arabian Town*' (Ph.D. thesis, University of Sheffield, 1988). To be published in part by Islamic Arts Trust, London, late 1999.
3. C. Hardy-Guilbert & C. Lalande, *Sheikh Isa House in Bahrain* (Paris, 1981); R. Al Oraifi, *Architecture of Bahrain* (Bahrain, 1978); G. King, '*Bayt al Muayyed: a Late Nineteenth Century House of Al Bahrayn' in Journal of Arabian Studies, 4 (1977), pp.27-45; R. Lewcock, Bahrain: a Consultants' Report. Conservation, Restoration & Presentation of Archaeological Monuments and Sites of Islamic Periods.* UNESCO (undated); & S. Roaf, '*Windcatchers of the Middle East*' in A. Germen (ed.), *Islamic Architecture and Urbanism: Symposium at King Faisal University*, Saudi Arabia (Dammam, 1983).
4. The periods are identified in Yarwood, thesis, Ch. 5. The Middle Period is that of major Persian influence, and the Late Period is (arguably) a degeneration of this, characterised by poor craftsmanship and eclecticism.
5. M. Rumaihi, *Bahrain: Social and Political Change since the First World War* (1976).
6. India Office Records, file IOR/15/2/1309.
7. F. Khuri, *Tribe and State in Bahrain* (Chicago, 1980).
8. Translated as : "*In the streets of Bandar Abbas, the Persian and Arab houses are distinct, and special characteristics belong to each. The first are gracious and decorative, and the second are heavy and massive.*" D. de Rivoyre, *Ovock, Mascate, Bouchire, Basorah* (Paris, 1883).
9. R. Lewcock & Z. Freeth, *Traditional Architecture in Kuwait and the Northern Gulf* (1978).
10. S. Zwemmer, *Arabia, Cradle of Islam* (New York, 1900).
11. The "Arab Style" probably arose in the distant past in Mesopotamia. Mallowan & Woolley prepared a reconstruction of an excavated house at Ur, and expressed the opinion that the typical Larsa house (1800 B.C.) resembled late 19th century houses in Baghdad. The survey of the layout of a Sumerian housing district excavated by Mallowan & Woolley is almost identical to the layout of traditional Islamic cities, including Al Muharraq up to the mid 1920s. See Sir M. Mallowan & Sir L. Woolley, *Ur Excavations*, Vol. VII, *The Old Babylonian Period* (1975). See also R. Lewcock, '*Background Paper: Bahrain*', unpubl. notes for Aga Khan Programme for Islamic Architecture, MIT (1986) & A. Moortgat, *Art of Ancient Mesopotamia* (1969), plate L1 & p.5 regarding ancient Mesopotamian antecedents.
   For indications that the Sumerians migrated from the east via Bahrain, see Major-General Sir H. Rawlinson, '*Notes upon Captain Durand's Report upon the Islands of Bahrein*' in *Journal of the Royal Asiatic Soc.* 12 (1880). Note that construction methods in the Indus Valley civilisation, (Harappa, Mohenjo-Daro,) resemble Mesopotamian methods more than Indian ones. Bahrain lies between the two; there is evidence of its role as an entrepot at the period. On the diffusion of Arab methods to east Africa, see R. Lewcock, '*Zanj-the East African Coast*' in P. Oliver (ed.) *Shelter in Africa* (1971).
12. Regarding diffusion of Persian methods south across the Gulf, Lewcock mentions the palaces at Qaleh i Dukhtar and that of Ardashir at Firuzabad to indicate the continuation of the buttress/niche system in Sassanian design. Persia was able to develop a more refined aesthetic and a more sophisticated construction method, on the basis of Saljuq influence as well its greater natural wealth and centralised civilisation, compared to the tribal and impoverished *Arabia Deserta*. Masonry vaulting encouraged reliance upon columnar construction, and lightweight enclosure (and height), captured the cooling effects of breezes and encouraged rapid cooling of walls at night. See eg, Fatemah Taghi, '*Ardakan*', (Ph.D. thesis, Glasgow University, 1988). From an ethnographic standpoint, note that many Arabs migrated to the Persian coastline in the 17th century and thereafter, returning sporadically to Bahrain, Zubara, Dubai, etc. They were known as *Huwalah* (or "returned") Arabs, and together with Persians constituted the intellectual and commercial elite of Bahrain throughout our period. See M. Al Tajir, *Language and Linguistic Origins in Bahrain*, (1982), pp.17 & 33; & Capt. R. Taylor, 'Extracts from *Brief Notes Etcetera*' in Bombay Selections XXIV, Govt. of India (1856).
13. Battlement placed upon the roof parapet, originally military in purpose, but after mid-nineteenth century, becoming purely decorative.
14. Author's informants: Abdul Wahed, Hamza Mohammed, Hassan Seyadi, Yusuf Abdullah, Sheikh Khalifa bin Abdullah al Khalifa, Yusuf Mattar, Mariam al Jalahma, Eid Bokhammas (whose family founded the first builders' merchants in 1878).
15. Reports by Political Agents, quoted here, on file 10-R/15/2/52-3/1, India Office Records.
16. 10-R/15/2/52-3/1 India Office.
17. A. Faroughy, *Bahrain Islands* (New York, 1951), p.46.
18. C. Hardy-Guilbert & C. Lalande, *Sheikh Isa*, House p.103.
19. This refers to Bandar Lingeh, a town on the Persian Coast.
20. The Early Period represents the basic and rather crude "Arab Style", and the Transitional period is a flowering of that style during increasing prosperity, displaying also marginal Persian influence. See Yarwood, thesis, Ch. 5.
21. For a fuller account, see Yarwood, thesis, p.143.
22. Capt. R. Mignan, *A Winter Journey through Russia, the Caucasian Alps and Georgia into Koordistan*, (2 vols. 1839), 2, p.106.
23. Quoted in T.A. Anthony (1984), *Documentation of the Modern History of Bahrain from American Sources* (1900-1938), *Historical Records of the Arabian Mission; New Brunswick, New Jersey* in *Al Watheeka*:4; (Bahrain 1984).
24. Dr W. Harrison, *The Arab at Home* (New York, 1924), p.27.
25. Anthony *Documentation*.
26. Anthony *Documentation*.
27. Govt. of Bahrain, *Population Census 1979 & Population Census 1981.*
28. Lewcock & Freeth, *Traditional Architecture* (1978), p.6.
29. 10-R/15/2/52-3/1 India Office.